Remarks and Arguments

The examiner has carefully identified certain minor grammatical errors in various sections of the specification. For each of the items listed in the examiner's rejection, the applicants have amended the text to address the examiner's concerns in this regard. Reconsideration of the specification under this ground for objection is therefore respectfully requested.

Claim 1 was objected to because the examiner found that lines 8-11 of the claim were written in an "unclear manner." Amendments have been made to each of the claims of the application, including Claim 1 in an attempt to clarify them without changing their scope. Reconsideration of Claim 1 under this ground for objection is respectfully requested.

Claims 1 and 3-6 were rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 5,742,049 ("Holle"). In making this rejection, the examiner has stated that Holle discloses an ion beam that "is directed into a pulser that accelerates and pulses the beam." The examiner has also stated that Holle discloses a reflector, a detector and gridless slit diaphragms. However, a careful comparison between Holle and the present invention reveals some very fundamental differences between the two.

Holle discloses a method of improving mass resolution in time-of-flight mass spectrometers. As noted by the examiner, Holle does include electrodes with gridless apertures. Holle also provides acceleration of an ion beam. However, this is where the similarities between Holle and the present invention end. As clearly shown in Figure 1 of Holle, the ion beam 12 proceeds in an axial direction through the accelerating gridless electrodes 2 and 3. The electrodes are used to accelerate the ion beam along its axis, and an Einzel lens consisting of electrodes 4, 5, 6 are used to compensate for divergence of the beam from the axis due to the gridless electrodes.

While the method of Holle provides a means for controlling the axial acceleration of an electron beam, it is completely different from the laterally accelerated ion beam of

the present invention. Whereas Holle controls the ion acceleration along an axis between the ion source and the detector, the applicants provide a system that relies on pulsing an ion beam laterally relative to the ion beam axis. This is very clearly described in applicant's disclosure and shown, for example, in Figure 1 of the application. The primary beam is injected parallel to the x-axis, and then accelerated by the pulser parallel to the y-axis, perpendicular to the x-axis. This creates a "band-shaped" ion beam that is then reflected in the y-dimension using the reflector consisting of diaphragms 5 and 6. The ions then fly toward the detector 9 as a band-shaped ion beam.

Obviously, the arrangement of applicant's system is fundamentally different from that of Holle. This was reflected in the claims as originally filed, which made it clear that the ion beam was accelerated in a direction perpendicular to the beam axis. It continues to be true in the claims, as amended. Claim 1 recites a time-of-flight mass spectrometer having ions that fly parallel to an x-axis and a pulser with a gridless slit diaphragm that accelerates the ions in a direction parallel to a y-axis, which is perpendicular to the x-axis. The claim also recites a reflector that receives the ion beam from the pulser and provides acceleration in a direction opposite that of the pulser. A detector is then recited that receives and measures the ions temporally. The gridless diaphragms of the pulser and the reflector are specified in the claim as providing focusing of the ion beam parallel to a z-axis, which is perpendicular to the x-axis and y-axis. None of these features is even remotely suggested by the Holle reference. Moreover, since Claims 3-6 each depend ultimately from Claim 1, each of these claims is also completely unsuggested by the cited prior art. Reconsideration of Claims 1 and 3-6 under this ground for rejection is respectfully requested.

Claim 2 was rejected under 35 U.S.C. §103(a) as being obvious over Holle in view of U.S. Patent No. 5,955,730 ("Kerley"). In making this rejection, the examiner has stated that Holle fails to show the use of a two-stage reflector, but that Kerley shows such a device. Without commenting on Kerley's applicability in this regard, it is noted that, like the Holle reference alone, the combination of Kerley and Holle fails to disclose

the invention as recited in applicant's Claim 1, including the lateral acceleration of an ion beam and the use of a pulser and reflector with gridless diaphragms for the resulting band-shaped ion beam. Also absent is any suggestion of focusing a band-shaped ion beam in a direction perpendicular to an initial ion beam direction and the lateral acceleration direction. As such, this prior art combination likewise fails to suggest the invention of Claim 2. Reconsideration of Claim 2 under this ground for rejection is respectfully requested.

Claim 7 was rejected under 35 U.S.C. §103(a) as being obvious over Holle in view of U.S. Patent No. 5,065,018 ("Bechtold"). In making this rejection, the examiner has stated that Holle fails to show a mass spectrometer that uses a pulser having two slit diaphragm electrodes and a repeller electrode. Bechtold is therefore cited as showing such a feature. Without commenting on the applicability of Bechtold in this regard, it is noted that the combination of Holle and Bechtold still fails to disclose, much less suggest, a system in which a pulser accelerates an ion beam perpendicular to the initial direction of beam travel, and in which the pulser and a subsequent reflector use gridless diaphragms to accelerate the ion beam. Also absent is any suggestion of focusing a band-shaped ion beam in a direction perpendicular to an initial ion beam direction and the lateral acceleration direction. This prior art combination therefore clearly fails to suggest the invention of Claim 7. Reconsideration of Claim 7 under this ground for rejection is respectfully requested.

Claims 8 and 9 were rejected under 35 U.S.C. §103(a) as being obvious over the prior art combination of Holle and U.S. Patent No. 6,469,295 ("Park"). In making this rejection, the examiner has stated that Holle fails to show rotation of reflectors about the x-axis so as to form a zig-zag beam and deflection of the beam in the y-direction using an electric capacitor field. However, without commenting on the specific details of Park, it is apparent that the combination of Holle and Park again fails to disclose, much less suggest, the rudimentary features of applicant's claimed invention. Nowhere in the cited prior art combination does there appear to be any suggestion of a system that uses the lateral acceleration of a ion beam with a pulser having gridless diaphragms. Likewise,

nowhere does there appear to be a suggestion of a reflector with gridless diaphragms, or focusing of a band-shaped ion beam in a third direction perpendicular to the beam axis and the acceleration directions. As these features are very clearly recited in Claim 1, from which Claims 8 and 9 depend, there is no suggestion of these claims by the cited prior art combination. Reconsideration of Claims 8 and 9 under this ground for rejection is respectfully submitted.

In light of the foregoing amendments and remarks, it is respectfully requested that all the claims be allowed such that the application may be passed to issue. If it is believed that a telephone conference will help expedite prosecution of the application, the examiner is invited to call the undersigned. The Commissioner is hereby authorized to charge any additional fees due for the filing of this paper to applicant's attorneys' Deposit Account No. 02-3038.

Respectfully submitted

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Version Marked to Show Changes

In the Specification

Paragraph beginning on page 2, line 12

In the simplest case of a TOF mass spectrometer, the ions are not focused at all. Acceleration of the ions generated by MALDI or ESI is performed by one or two grids, and the slight divergence of the ion beam caused by the initial velocities of the ions perpendicular to the direction of acceleration is accepted as being tolerable. The reflector also contains grids, one or even two grids depending on the type of reflector. In addition to beam divergence due to the spread of initial velocities there is a beam divergence caused by the small-angle scatter at the openings of the grid. If the electric field strength is different on both sides of the grid, each opening in the grid will act as a weak ion lens. Divergence due to the spread of initial velocities can be reduced by selecting a high acceleration voltage but the small-angle scatter at the openings in the grid cannot be reduced. This small-angle scatter can only be reduced by making [finer and finer-mesh] nets of finer mesh, [however] albeit at the expense of grid transparency. Beam divergence creates a larger beam cross-section at the location of the detector, which necessitates a large-area detector. This large-area detector has disadvantages: a high level of noise and the necessity of very good two-dimensional directional adjustment in order to keep the flight path differences well below one micrometer.

Paragraph beginning on page 2, line 27

For an optical system with two acceleration grids and one two-stage reflector with two grids, which each have to be transversed twice, there are already six grid passages. Even if the grids have a high level of transparency at 90%, which can only be achieved if the thickness of the grid wires is only about 5% of mesh size, total transparency is still only 48%. In addition there will be a [no longer negligible] non-negligible number of ions which are reflected by the grids and can be scattered back to the detector where they create background noise, which worsens the signal-to-noise ratio.

Paragraph beginning on page 3, line 11

All the mass spectrometers known [to date] for orthogonal injection, however, have the [basically] very disadvantageous grids (due to the band-shaped ion beam which does not permit spherical lenses), both in the pulser and in the reflector.

Paragraph beginning on page 3, line 19

Throughout this text, we shall use the following nomenclature:

1) the original flight direction of the orthogonally injected ions defines the x-direction,

2) the direction[, into] <u>in</u> which the ions are pulsed by the pulser[,] defines the y-direction,

3) the z-direction is defined to be perpendicular to the x- and y-direction.

The three directions are orthogonal to each other; the y-direction is not completely identical with the flight path of the ions after being pulsed by the pulser.

Paragraph beginning on page 4, line 15

Since the z-divergence of the ion beam leaving the pulser necessitates very wide slit diaphragms at the two-stage reflector, it is useful to install a cylindrical lens [here too] between the pulser and the reflector, making the ion beam narrower in the z-direction. The cylindrical lens can be a cylindrical Einzel lens. It is particularly advantageous to place the cylindrical lens close to the pulser and set it electrically so that an initial focusing in the z-direction is achieved between the pulser and the reflector. A focus line is formed, expanded linearly in the x-direction (almost perpendicular to the direction of flight) and located between the pulser and the reflector. This focus line is then focused, in <u>the</u> z-direction, onto the detector by the two-stage reflector. Another reason why installation of the cylindrical lens is particularly advantageous is that the ratio between deceleration field strength and reflection field strength in the reflector not only sets spatial z-focal length but also velocity focusing (and hence temporal focusing) at the detector, which takes absolute priority in achieving a high temporal resolution (and therefore mass resolving power). The cylindrical lens thus makes it possible to set the focusing length of the entire arrangement in the z-direction irrespective of velocity focusing.

Paragraph beginning on page 6, line 10

Figure 3 shows [an also] <u>a</u> possible convolution of the band-shaped ion beam in the x-y plane. The designations are the same as in Figures 1 and 2.

Paragraph beginning on page 7, line 8

The ions which have left the pulser now form a wide band, whereby ions of the same type [are always] form a linear segment in <u>the</u> x-direction flying nearly in <u>the</u> y-direction. Light ions fly faster, heavy ones slower, but they all fly in the same direction. The drift section of the time-of-flight mass spectrometer must be completely surrounded by the acceleration potential (not shown in Figure 1 for reasons of simplicity) in order not to disturb the ions in their flight.

<u>In the Abstract</u>

Abstract

The invention relates to a time-of-flight mass spectrometer for injection of the ions orthogonally to the time-resolving axis-of-flight component, with a pulser for acceleration of the ions of the beam in the axis-of-flight direction, [preferredly] <u>preferably</u> with a velocity-focusing reflector for reflecting the ion beam and with a flat detector at the end of the flight section. The invention consists of using, both for acceleration in the pulser and for reflection in the reflectors, a gridless optical system made up of slit diaphragms which can spatially focus the ions onto the detector in the direction vertical to the directions of injection and flight axis, but which does not have any focusing or deflecting effect on the other directions. For some reflector geometries it is essential to use an additional cylindrical lens for focusing, and for other reflector geometries the use of such a lens may be advantageous.

<u>In the Claims</u>

1. (*Amended*) [Time-of-flight] <u>A time-of-flight</u> mass spectrometer with injection of a narrowly defined ion beam[, comprised of] <u>having</u> ions which fly in a [so defined x-direction] <u>direction parallel to an axis x, the spectrometer comprising:</u>

[into] a pulser which accelerates, in pulses, a segment of the ion beam [in a so defined y-direction] with a gridless slit diaphragm that extends parallel to the x-axis, the acceleration being parallel to an axis y that is perpendicular to the [x-direction and forms] x-axis so that the accelerated ions form a band-shaped ion beam;

[, with] at least one electrical reflector [for reflection of the ion beam in the y-direction] that receives the ion beam from the pulser and accelerates it with a gridless slit diaphragm that extends in the x-direction, the reflector acceleration being in a direction opposite to the acceleration provided by the pulser; and

[one] a detector [for] that receives the reflected ion beam from the reflector and provides temporally resolved measurement of the ion beam, wherein [the pulser and the at least one reflector use for ion beam passage gridless slit diaphragms extended in x-direction which, either as such or in conjunction with other cylindrical ion optical lenses extended in the x-direction, can focus] the gridless slit diaphragms of the pulser and the reflector provide focusing of the ion beam on the detector in a [z-direction] direction parallel to an axis z that is perpendicular to both the [x- and y-direction] x-axis and the y-axis.

2. (*Amended*) [Time-of-flight] A time-of-flight mass spectrometer according to Claim 1, wherein the spectrometer includes at least one two-stage reflector with two slit diaphragms, one short deceleration field and one reflection field [is used which acts on the band-shaped] that contribute to said ion beam focusing [in the z-direction and can focus it on the detector in the z-direction].

3. (*Amended*) [Time-of-flight] A time-of-flight mass spectrometer according to Claim 1, [wherein] further comprising at least one cylindrical lens [extended in the x-direction is present for] that extends parallel to the x-axis and contributes to said focusing of the band-shaped ion beam [in the z-direction so that the system of slit diaphragms of the pulser, slit diaphragms of the reflectors and cylindrical lenses can focus the ion beam on the detector in the z-direction].

4. (*Amended*) [Time-of-flight] A time-of-flight mass spectrometer according to Claim 3, wherein the spectrometer comprises at least one cylindrical Einzel [lenses] lens made up of two outer slit diaphragms at ambient potential and one inner slit diaphragm at a lens potential [are used].

5. (*Amended*) [Time-of-flight] A time-of-flight mass spectrometer according to Claim 4, wherein only one cylindrical Einzel lens is used which is positioned very close to the pulser, [whereby in the] such that in a boundary case of diminishing distance the pulser and cylindrical Einzel lens have a common slit diaphragm.

6. (*Amended*) [Time-of-flight] A time-of-flight mass spectrometer according to Claim 4, wherein [the two jaws of the inner slit diaphragm of] the cylindrical Einzel lens has an inner slit diaphragm with two jaws that can be connected to slightly different potentials for adjusting the direction of the band-shaped ion beam in the z-direction.

7. (*Amended*) [Time-of-flight] A time-of-flight mass spectrometer according to Claim 1, wherein the pulser has two slit diaphragm electrodes and one repeller electrode, of which only the repeller electrode, the first slit diaphragm or both together are used for pulsing the ions located between the repeller electrode and the first slit diaphragm by means of voltage changes, while there is constant potential at the second slit diaphragm.

8. (*Amended*) [Time-of-flight] A time-of-flight mass spectrometer according to Claim 1, wherein at least two reflectors are used which are slightly rotated round the x-axis, so that the ion beam is slightly reflected out of the x-y plane in the z-direction forming a zig-zag beam in the projection onto a y-z plane.

9. (*Amended*) [Time-of-flight] A time-of-flight mass spectrometer according to Claim 8, further comprising an electrical capacitor that generates a capacitor field parallel to the x-axis and that deflects [wherein] the band-shaped ion beam

[which,] in a direction parallel to the y-axis after [leaving] it leaves the pulser [and having a direction component in the x-direction, is deflected into the y-direction by an electric capacitor field in the x-direction].